

E2 Present (and Future) Classic Circuits with Less Than 25 Transistors

Organizer: JoAnn Close, Analog Devices, San Jose, CA

Chair: Bill Redman-White, Philips Semiconductors and Southampton University, Southampton, United Kingdom



Although possibly the “oldest profession” in the electronics business, active circuit design is still home to challenge and innovation, even when the transistor count is in the tens and not millions. Despite predictions that there are no new circuits to be invented, new topologies with only a handful of transistors continue to be presented. Some are useful, but many are not, forgotten quickly like cheap wines. A select few live on as instant classic vintage. These are the sound choices of the past and the present, and will probably be brought to the table for many years to come.

Different things can make a circuit great and memorable. Some are a reliable choice for a wide range of applications, relied upon by armies of designers to deliver against the menu on the spec sheet. Some circuits hit a particular spot in the commercial world and have made companies' fortunes. Others have a more limited range of application, but continue to impress and intrigue with some intrinsic elegance of form and function. We can also ponder which circuits will season and mature with the passage of time and the shrinking of technology, and those which will be left in the cellar. Technology is also a factor; what is a real favourite in bipolar can be just plain mediocre in CMOS or not work at all.

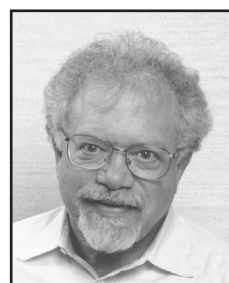
In this panel we ask for the connoisseurs' nominations of great circuits with fewer than 25 transistors from the last 20 years, and those most likely to be on the table in the next 10 years in the nanometre era.

Panelists Statements



Klaas Bult, Broadcom, Bunnik, The Netherlands

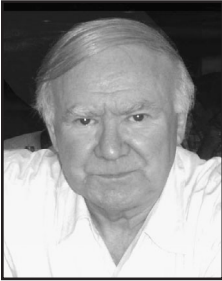
It is well known that, even for the most brilliant circuits, obtaining excellent results requires 10% inspiration and 90% transpiration. However that 10% of inspiration is often the most intriguing part. Analog design is often referred to as an Art and in a certain sense it is. If a certain design is elegant or beautiful, 9 out of 10 analog engineers will recognize it as such. And like in real Art, there may be differences in opinions and it may also be hard to pin-point what makes it beautiful or elegant. I think simplicity is a very important aspect, both in the circuit itself as well as the explanation of it. In my choices for this panel I will focus most on these aspects.



Bob Dobkin, Linear Technology, Milpitas, CA

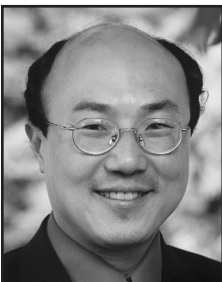
Designing linear circuits is like using a language. Small simple concept circuits are combined to produce the final result. These small circuits are the vocabulary of analog designers. Made of a few transistors, they perform a specific functions and are reused time after time. IC designers are familiar with some such as: bandgap, peaking current source, diff-amp, OTA, and even, the more complicated op-amp. Over the past 30 years, new circuits have gradually increased this working vocabulary and I am sure that more will come.

Panelists Statement



Barrie Gilbert, Analog Devices, Beaverton, OR

Circuits - a few hundred elements - are the cooperative blocks of Products. Cells are areas of a circuit where a few transistors perform unique functions of a characteristic and fundamental sort - such as a current mirror. The exceptional potency and versatility of a select group of cells has earned them a broad following. Some can justly be called amazing. Many continue to gain value, yielding to topological tinkering. The panel will share their all-time favorites



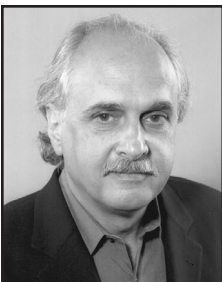
Tom Lee, Stanford University, Stanford, CA

Does "classic" connote novelty and utility together, or just utility (and therefore, popularity)? As co-panelist Prof. Tsividis has pointed out, Maxwell showed the equivalence of a switched capacitor to a resistor over a century ago (see "A Treatise on Electricity & Magnetism" v.2, pp. 420-421). Novelty is evidently a tough criterion to satisfy! Not surprising, then, is that the allegedly classic circuits devised in the last two decades are largely inevitable, though clever, rehashings of old (often very old) ideas.



Takahiro Miki, Renesas Technology, Hyogo, Japan

In the analog area, if one is asked to select the best invention in the past two decades with no restriction of device count, he/she may pick up an invention of architecture (i.e. A/D conversion architecture) rather than a circuit technique of 1-25 transistors. More than thousands of transistors were already available on a die for analog functions two decades ago. This large-scale integration has been enabling and has forced analog circuit designers to pursue innovation and optimization of architecture. Naturally such innovative architecture-level techniques have been highlighted. However, innovations of small circuits are also very important because they are keys to extracting advantages and avoiding problems in a fine process, and to realizing architecture-level ideas. Among such excellent small circuits, a really excellent one has a surprisingly simple structure, is easy to implement on silicon, improves performances with almost no penalty or cost, and solves problems common to designers. In addition, it is difficult for everyone to find a substitution for it.



Yannis Tsividis, Columbia University, New York, NY

What are the ingredients in the invention of a good circuit? In most cases, several among the following: A solid understanding of circuits principles and, in some cases, device physics; a good understanding of what's wrong with previous approaches, if any exist; a sense for elegance and minimality; the ability to think laterally; the blessing of a computer crash, so that the designer can think rather than simulate incessantly; and finally, sheer luck.